Chapter 7
Inspection, Maintenance, Retirement, Etc.

7-1. Inspection

a. Frequency of inspection. The frequency of inspection required for wire rope at Corps facilities varies considerably, depending on usage, the environment the rope is subjected to, and the lubrication program. The inspection program should be formulated during the formulation of a project's O&M manuals. At some Corps facilities the gates are rarely operated, and the ropes are of stainless steel, making annual inspections adequate. At other facilities, gates are operated many times per day, and monthly inspections may be appropriate.

b. Rope indicators.

(1) Diameter reduction. The diameter of wire rope reduces as it degrades from abrasion, corrosion, inner wire breakage, stretch, etc. A rope's diameter should be measured when new and periodically throughout its life (at the same loading and in the same areas). A one-time comparison between a rope's measured diameter and its nominal diameter is not a true indicator of its condition. Measured diameters must be recorded and kept for historical reference. This procedure will typically show a rapid initial reduction in the rope's diameter followed by a slower more linear reduction. A sudden diameter decrease marks core deterioration and indicates a need for replacement.

(2) Stretch. Before rope installation is performed, a method should be devised to periodically measure rope stretch (at the same loading). Rope stretch typically occurs in three distinct stages (Figure 7-1). The first stage is constructional stretch as discussed in Section 4-7, "Rope Length/Stretch." It is rapid and of a short duration and can be reduced by pre-stretching. In the second stage, a small amount of stretch takes place over an extended time. This results from normal wear, fatigue, etc. The third stage is marked by an accelerating rate of stretch. This signals rapid degradation of the rope from prolonged wear, fatigue, etc. Replacement is required when the rope enters this stage.

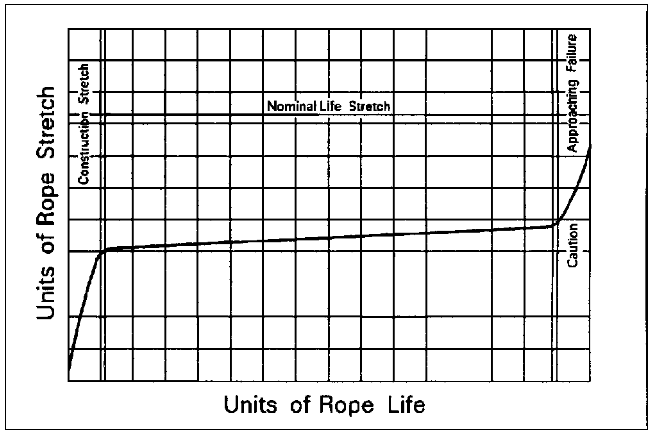

Figure 7-1. Rope life versus stretch

(3) Abrasion. Most standards require rope replacement when the outer wire wear exceeds 1/3 of original wire diameter. Since wear occurs mostly on the outer wires' outer surfaces, measuring or determining the exact amount of wear is difficult. Dismantling and measuring wire diameters of discarded ropes can provide training for the inspector.

(4) Broken wires. The number of broken wires on the outside of a wire rope provides an index of its general condition. Wire rope on gate-operating devices should be replaced if the number of broken wires per lay length reaches 6, or if the number of broken wires per strand rotation length reaches 3. If more than one wire fails adjacent to a termination, the rope shall be replaced immediately. It is common for a single wire to break shortly after installation, which may not be a concern. However, if more wires break, the situation should be investigated. Once breaks begin to appear, many more will generally occur within a relatively short time. Attempts to get the last measure of service from a rope can create a dangerous situation. Broken wires in the valleys of rope (between the strands) indicate a very serious condition. When two or more such fractures are found, the rope should be replaced immediately. A determination of the cause of wire breaks should be made before replacing the rope. Figure 7-2 shows various types of breaks.

(5) Corrosion. Corrosion may be the most common and serious form of rope degradation on gate- lifting devices. There is no known method of calculating the strength of a corroded rope. It will

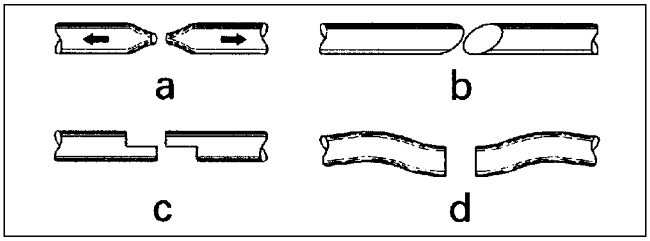

Figure 7-2. Various types of wire breaks: (a) a ductile failure from too great a load, (b) a shear-tensile failure from a combination of transverse and axial loads, (c) and (d) breaks from fatigue

often occur internally before any evidence appears on the external surface. A slight discoloration from rust is usually just an indication that lubrication is overdue. However, severe rusting leads to fatigue failure, especially in areas that normally would not fail, such as near terminations, where bending is not required. Pitting is the worst form of corrosion. If pitting is observed, the rope should be replaced. Not only do the pits damage the wires on which they occur, they also prevent the rope's component parts from moving freely when moving over sheaves and drums. This contributes to abrasion and fatigue.

(6) Peening. Continuous pounding is one cause of peening. It can occur when a rope vibrates against another component, or if a rope is continuously worked against a drum or a sheave at a high pressure. The appearances of peening and abrasion are compared in Figure 7-3. Heavy peening can result in wires cracking and breaking and may eventually require rope replacement.

(7) Scrubbing. Scrubbing occurs when a rope rubs against itself or another object. Its effects are normally evident on only one side of a rope. If corrective measures are not taken in time, rope replacement may be required.

(8) Localized conditions. It is typical for gate-operating devices at some Corps installations to position their rope at one or two locations most of the time. This concentrates wear or damage at these areas. Also, special attention should be given to rope in the areas of equalizing sheaves. Only slight movement occurs over them, usually a rocking motion. This causes a concentration of bending and abrasion where the rope meets the sheave groove. Look for worn and broken wires. Note that this is an area where deterioration may not be readily detected. Careful checking and operating of the device may be required to make rope damage more visible. End fittings are especially susceptible to damage if they are submerged. This would require the gate to be lifted for the inspection.

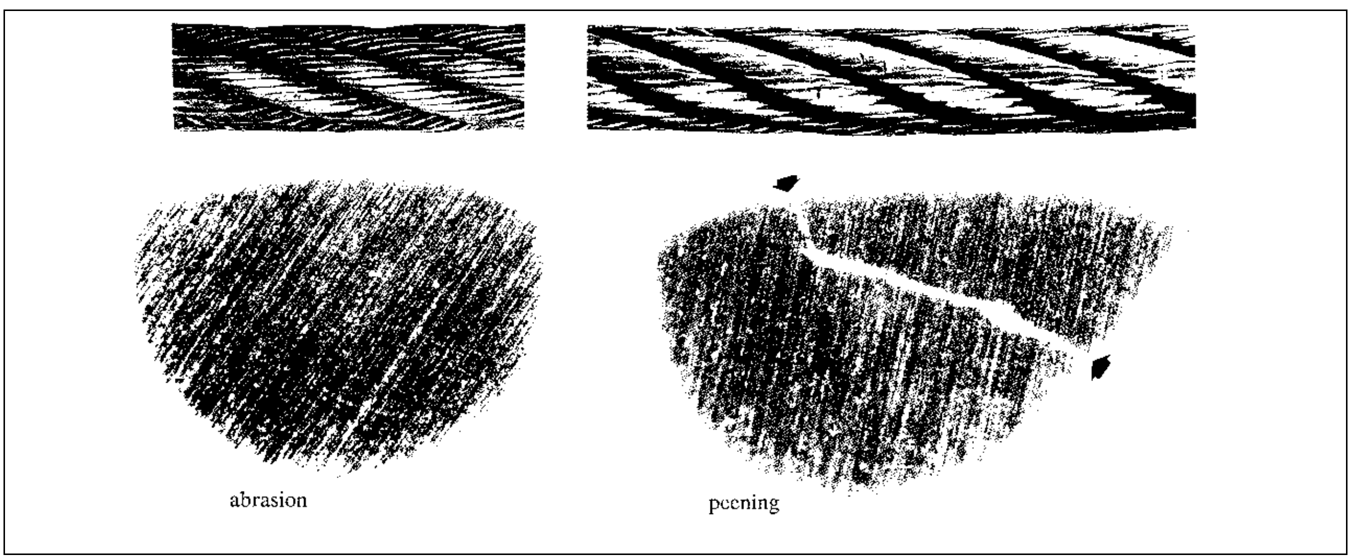

Figure 7-3. A comparison of abrasion and peening: Abrasion wears away wire material. Peening swages and fatigues. Notice the crack between the arrows

(9) Other forms. There are several other forms of rope damage, all of which call for immediate rope replacement. They include kinks, bird caging, protruding cores, and heat damage. Kinking is discussed in Section 6-2, “Storage, Handling, and Unreeling.” Bird caging is a separation of the strands or wires resulting from shock or sudden loading. Any time a rope’s core is visible, the rope must be replaced. Heat damage is usually evident as a discoloration of the rope wires, and also calls for rope replacement.

(10) Over-stressing. There have been occasions when a gate-operating device jams, or one or more ropes on a multi-rope device breaks. On these occasions a rope (or ropes) have been overstressed compared to their design load. Determining if the rope was damaged may be impossible. In some instances damage may be indicated by a change in lay length. If so, the area of change may be small, so finding this evidence may be difficult. If a wire rope has been damaged because of overstressing it should be replaced. If damage is suspected, but not proven, it is better to err on the conservative side. As a minimum, the potential of overstressing must be considered at the end of the rope’s projected service life (See Section 7-2, “Retirement”).

c. Indicators for sheaves, etc. Inspection of sheaves, pulleys, drums, fittings, and any other machine parts or components coming into contact with the rope is also required. The inspection of these components should be performed at the same time as the wire rope inspection and the results should likewise be documented.

(1) Sheaves, pulleys, and drums. The first item to be checked when inspecting sheaves, pulleys, roller guides, and (grooved) drums is groove size. This is done with “go” and “no-go” gauges as shown in Figure 7-4. Second, the condition of the grooves must be inspected. The pattern of the rope may be imprinted in the groove. If so, rope wear will be greatly increased. Third, the inspector should check for wobble in the bearings, broken flanges, flat spots, or off center groove wear.

(2) Fittings. Cracked, bent, worn, or broken fittings must be replaced. Look for broken wires and loose or damaged strands adjacent to fittings. If more than one wire has failed adjacent to a termination, the rope should be replaced immediately.

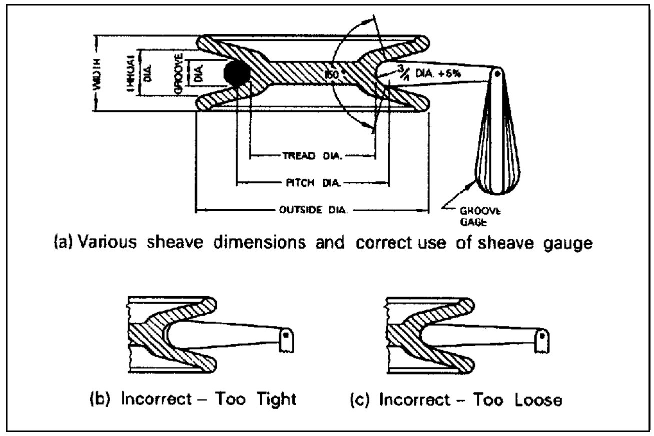

Figure 7-4. Measuring groove diameter with a Go/No-Go gauge

d. Inspection reports. In addition to planning and carrying out an inspection program, it is necessary to store and analyze the data. A sample inspection report form is included in Appendix G. It is recommended that inspection reports be signed and dated. They should be kept for the life of the rope and after its replacement. The report data should be compared with data from previous reports to identify any trends that may occur.

7-2. Retirement

a. Service life. Section 7-1 discusses wire rope inspection, and gives some criteria for retirement. However, it is recommended that wire rope used on gate-operating devices be assumed to have a maximum service life of 20 years. Devices with previous records of short rope life should be assumed to have a shorter rope service life.

b. Failure analysis. A failure analysis should be performed on any retired rope to determine its prime failure mode(s) so a replacement rope can be selected with a cost effective service life.

c. Disposal of wire rope. The disposal of failed or retired wire rope may pose a problem. Wire rope is not easily processed by the shredders used to prepare scrap metal for re-melting. Lubricated wire rope cannot be buried in landfills in some states. Also, sizes

13 mm (1/2-in.) through 22 mm (7/8-in.) used wire rope is suitable for drag line use. However, most wire rope used for gate-operating devices is larger and is not in demand in a used condition. If replacement rope will be installed by contract, having the contractor “remove and dispose of properly” may be the best option.

7-3. Lubrication

a. Rope lubrication. There are two reasons for lubricating wire rope, wear reduction and corrosion reduction. Ropes are usually lubricated by the manufacturer during fabrication. The manufacturer will generally have shop equipment which can force lubricant into the core area of the rope. The initial treatment is generally adequate for transport and storage, and it will usually protect the rope for a short time after initial use. However, it will usually not provide the lubrication needed for the rope’s full life. Periodic cleaning and lubrication are usually necessary. A rope can be cleaned with a stiff wire brush dipped in solvent, with compressed air, or with superheated steam. The object of cleaning is to remove any foreign material and old lubricant from the valleys between the strands and from the spaces between the outer wires. New lubricant is applied by continuous bath, dripping, pouring, swabbing, painting, or by spray nozzle In selecting the type of lubricant, a number of issues need to be considered such as:

(1) Clear lubricant may be required for exterior rope inspection.

(2) Hot weather conditions may liquefy normal lubricant.

(3) High frequency or unusual amount of lubricant may emphasize cost.

(4) Special environmental requirements may limit lubricant selection.

Specific brand names and types of lubricants are listed and discussed in Appendix H. Also, not lubricating may be considered in situations where the rope is stainless steel and operation is infrequent. Lubrication can seal moisture in the voids between the rope wires and on their outer surfaces causing corrosion. Tests have indicated that corrosion will be less severe for a non-lubricated rope than for one which is infrequently lubricated. Infrequent lubrication causes areas on a rope’s surface to have no lubricant for extended periods of time. In humid atmospheres, or submerged conditions, this produces corrosion cells which cause deep pitting. If a rope is not lubricated, corrosion tends to be shallow and over a large area. The deep pits on the infrequently lubricated rope are much more damaging than loosing a thin layer of metal over a large area. Also, if a rope is frequently lubricated, the corrosion cells may still form, but their duration will be shorter, and their locations change the each time the rope is lubricated. Consequently, a greater number of pits may occur, but they tend to be shallow. Again, the deep pits on the infrequently lubricated rope are much more damaging. For additional information on wire rope lubrication, refer to the upcoming Engineer Manual on lubrication.

b. Sheave lubrication. Sheave bearings should be lubricated periodically. Increased friction at wire rope sheaves can significantly affect the tension required to lift a given load (Section 4-2, “Calculating Rope Load”). Lubrication points for sheaves should be in accessible locations. If this is not true for existing equipment, modifications should be considered.

7-4. Ice and Debris Removal

The presence of ice or debris in or on gates or gate-operating devices produces conditions of excessive stress, which may cause failure of ropes and other equipment. Ice may make gates impossible to move. Debris trapped in multi-line hoists can cause unequal tension in the ropes. Safety devices which limit rope tension can reduce the probability of such failures (Appendix E). Ice can be removed by spraying with cold or heated water, or to some extent, it can be prevented from forming with heated panels (Appendix I).

7-5. Painting

When painting is performed around wire ropes, special care should be taken to make sure that they are protected from overspray. Some paint contains chlorides (and other chemicals) which may contribute to or cause corrosion of the rope.

7-6. Cathodic Protection

Cathodic protection is often used for gates but is less often used for wire rope. Cathodic protection of submerged wire rope is possible, while protection of wire rope in damp environments is not. The sacrificial anode method, using magnesium anodes, is recommended over the impressed current method. The anodes must be grounded to the rope socket and located close to the rope sockets (see Sections 3-2, "Materials/Coatings" and 3-5, "Two-Piece Ropes").